

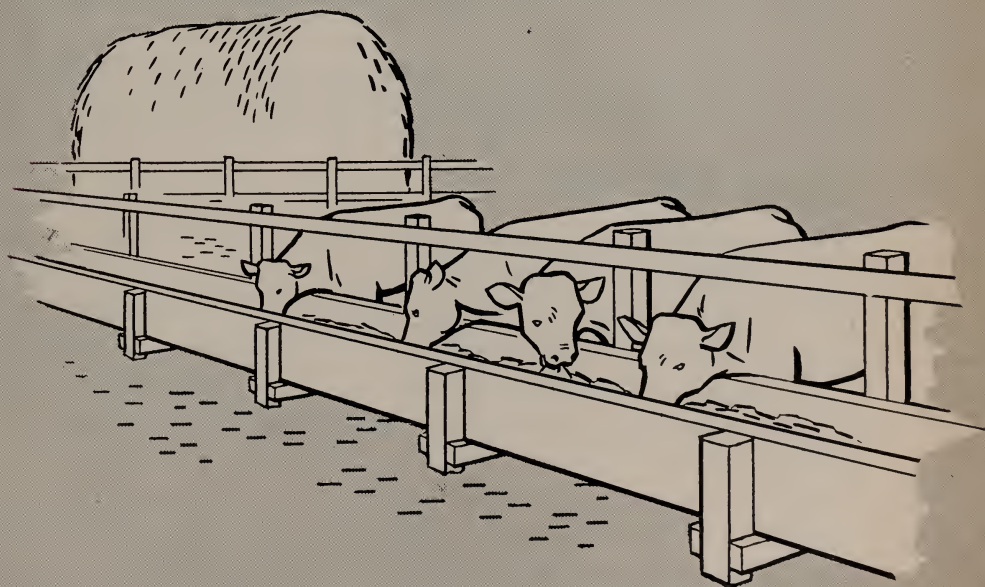
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FEEDING VALUE OF SUGAR-BEET BY-PRODUCTS

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TWO BY-PRODUCTS of sugar beets—sugar-beet tops and siloed beet pulp—contribute thousands of tons to the feed resources of California. Efficiency in the utilization of these feeds can be increased. Of sugar-beet tops, only a small part of the 200,000 to 300,000 tons produced annually are utilized; and of siloed beet pulp, ensilage losses amount to about 40 per cent. Tests have shown that

SUGAR-BEET TOPS HARVESTED AND SILOED OR STACKED

- contain 9.7 per cent digestible protein and 59.2 per cent total digestible nutrients on a dry basis
- are equal in total digestible nutrients to 450 pounds of barley or 700 pounds of alfalfa hay per ton
- may be successfully used for fattening cattle or lambs, wintering pregnant ewes, or feeding dairy cattle
- when fed in mixed rations, yield 150 to 250 pounds of beef or lamb per acre, two to three times as much as when tops are pastured
- eliminate the delay in soil preparation, and the spread of beet diseases and weeds that may occur when tops are pastured.

SILOED BEET PULP

- contains 8.9 per cent digestible protein and 76.4 per cent total digestible nutrients on a dry basis
- can be stored with less fermentation loss if a small percentage of molasses is added; and with greatly reduced total ensilage loss, as well as prevention of leaching, if 10 to 14 per cent barley is added
- can be improved in feeding efficiency by adding molasses.

At this period of high prices, beet by-products are a cheaper source of nutrients than most other feeds. Improved and increased use of these products could benefit both the sugar-beet grower and the livestock raiser.

FEEDING VALUE OF SUGAR-BEET BY-PRODUCTS¹

H. R. GUILBERT,² R. F. MILLER,² and H. GOSS²

INTRODUCTION

THE SUGAR-BEET industry offers two important by-products to the livestock industry: sugar-beet tops and siloed beet pulp. Both of these by-products are recognized as important feed resources. Their utilization is of mutual interest to livestock raisers and sugar-beet growers, and contribute to the economic stability of both industries.

In the United States, the prewar annual production of sugar beets was about 10 to 12 million tons. In California, for the same period, the annual production varied between 2 and nearly 3 million tons. Tonnage decreased about 50 per cent over the entire country for the period 1943-1945.

In California for the period 1935-1942, the annual dry matter yield of sugar-beet by-products varied from 200,000 to 300,000 tons of beet tops, and from 100,000 to 150,000 tons of beet pulp. This computation was based on tests, made at both the California and Colorado experiment stations, which showed the weight of moisture-free tops to be about 10 per cent of beet tonnage produced. Similarly, the average dry-matter yield of beet pulp is about 5 per cent of the tonnage of beets processed.

A considerable amount of work has been done in this country on the composition and utilization of beet tops, but apparently no work has been reported on the digestibility. In European countries, numerous trials have been made with sheep, but none with cattle. In California, probably less than half of the available beet tops is used for feed. Pasturing in the field is the common method of utilization, a simple but comparatively wasteful procedure.

Siloed beet pulp forms about one half the total pulp from the beet-sugar-factory output in California. It is stored as wet pulp in huge pits or silos, and the pulp is fed to livestock at the factory, itself, or is sold to near-by livestock producers. The other half of the total pulp is dehydrated with cane and beet molasses, and is sold as dried molasses beet pulp. Thus, according to the 1942 figure of 2.4 million tons of beets, there was produced in California that year wet pulp equivalent to 67,000 tons dry basis and about 95,000 tons of molasses dried pulp containing 30 per cent molasses.

So far as the authors are aware, no digestion trials have been run on wet beet pulp which has undergone fermentation in the silo, although trials have been run on dried beet pulp and on dried molasses pulp. A major problem arising from the storage of wet beet pulp in large open silos, or reservoirs, is

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the loss from fermentation, liquefaction, and drainage. The records of one important livestock feeder show a loss in dry matter of about 40 per cent. Possible methods for reducing losses of this nature are presented later in this publication.

SUGAR-BEET TOPS

Chemical Composition. The chemical composition of beet tops varies, especially with the soil and the environmental conditions under which the crop was grown, and with the relative amounts of leaves and crowns and adhering



Fig. 1.—Beet-top dry matter is equivalent to about 10 per cent of the weight of beets harvested, contains more digestible nutrients per pound than alfalfa hay, and yields one and one-half to two times the total nutrients obtained in beet pulp from the same beets.

dirt. Table 1 presents averages for American and European and California samples of beet tops; samples of crowns and leaves; and samples of beet-top silage. The maximum and minimum content of each constituent found in the various analyses is also given.

The analyses show large variations for all constituents. The true protein content of some samples, given in the original data, ranged from 58 to 74 per cent of crude protein. Thus, the tops contain a considerable amount of non-protein nitrogen. Ruschmann and Gräf (1931)³ found that the tops of sugar beets grown on marshy land heavily fertilized with nitrates were not satisfactory feed for livestock. The nitrate and oxalic acid contents were higher than was found in tops which were considered good livestock feed.

Beet tops contain considerable quantities of oxalates and oxalic acid. Oxalic

³ See "Literature Cited" for citations which are referred to in the text by author and date.

acid is known to cause intestinal irritation, to render calcium unavailable and to be toxic when unusual quantities are introduced into the blood stream. Some of the physiological effects of beet tops, including a tendency to produce urinary calculi, have been attributed to this constituent.

Table 1
CHEMICAL COMPOSITION OF BEET TOPS AND BEET-TOP SILAGE*

	Crude protein	Nitrogen- free extract	Ether extract	Crude fiber	Ash
	per cent	per cent	per cent	per cent	per cent
Beet tops (moisture-free)					
48 samples (American and European)					
Average.....	14.05	49.12	1.23	11.23	24.37
Maximum.....	18.08	63.00	2.80	17.27	41.40
Minimum.....	8.17	39.80	0.50	9.40	3.83
6 samples (California)					
Average.....	10.68	55.90	1.44	13.40	18.58
Maximum.....	18.08	63.00	2.70	16.10	19.60
Minimum.....	9.20	45.77	0.60	11.90	14.50
3 samples, crowns and leaves, separated					
Average					
Crowns.....	9.29	77.32	1.02	6.75	5.62
Leaves.....	14.91	42.60	1.63	17.47	23.39
Beet-top silage (moisture-free)					
41 samples					
Average.....	11.61	35.09	2.02	10.85	40.43
Maximum.....	15.90	49.45	3.62	14.69	64.82
Minimum.....	5.52	21.50	0.48	5.17	10.45

*Sources of data: Sherwood, S. F. Composition of sugar-beet pulp and tops and of the silage therefrom. U. S. Department of Agriculture, Dept. Cir. 319:1-11. 1924.

Eckles, C. H. Utilization of beet tops. Minnesota Agr. Exp. Sta. Special Bul. 129:1-7. 1930.

Honcamp, F., B. Gschwendner, and H. Müllner. Untersuchungen über den Fütterwert von getrocknetem, frischem und eingesäuertem Rübenkraut und Rübenblatt und über die Verluste an Roh- und verdaulichen Nährstoffen beim Einsäuern. Land. Ver. Stat. 88:305-78. 1916.

Spreckels Sugar Company, Woodland, California. Information to the authors.

California Agricultural Experiment Station. Unpublished data.

Neidig, R. E. Sugar-beet top silage. Idaho Agr. Exp. Sta. Cir. 17:1-4. 1921.

Morrison, F. B. Feeds and feeding. Appendix table 1. The Morrison Publishing Company, Ithaca, New York. 1936.

The crude-fiber content of beet tops, shown in table 1, is considerably lower than that of the common roughages. In dirt-free tops, the ash content is about 12 to 16 per cent of the dry matter; in the leaves, 20 to 27 per cent; and in the crowns, 5 to 7 per cent.

The mineral content of beet tops exceeds that in most feeds, and helps to explain their laxative nature. The very high ash content of most of the samples in table 1 is due to adhering dirt. Large amounts of dirt not only lower the value per pound by dilution, but also increase the laxative effect.

The moisture content of fresh beet tops is about 80 per cent; of field-dried tops 20 to 30 per cent; and of beet-top silage, 70 per cent.

Digestion and Metabolism Experiment with Yearling Steers. The beet tops used in this experiment were topped November 19 and 20, 1940, and piled in small cocks on November 20 and 21; the cocks were turned on November 26. Because of short days and cool weather, drying was slow. Three weeks later, after several days of dry wind, the leaves were finally dry, and the tops were stored in small ricks in an open shed. During subsequent wet weather, the leaves again became tough. The tops were turned to prevent heating. Some molding occurred. The moisture content of the tops fed to the cattle was 36.2 per cent. The tops consisted of 61.7 per cent leaves and 38.3 per cent crowns.

Two yearling steers, weighing about 800 pounds each, were used in the digestion and metabolism experiment. The animals consumed 22 to 25 pounds of tops daily, when given free access to feed, and since crowns were eaten in preference to leaves, consumption consisted of about 60 per cent crowns and 40 per cent leaves. To secure consumption of crowns and leaves in the naturally occurring proportion, and to avoid excessive weigh-back, the steers were limited to 16 pounds of tops daily during a 10-day preliminary, and a 15-day collection period. The animals apparently maintained weight during the trial.

The composition of the tops used in the experiment was determined by the standard methods of feed analysis and by partitioning the nitrogen-free extract and crude fiber into lignin, cellulose, according to Crampton and Maynard (1938), and other carbohydrates determined by difference. These percentages computed to the moisture-free basis are as follows:

	<i>Per cent</i>		<i>Per cent</i>
Crude protein	18.08	Lignin.....	6.78
Nitrogen-free extract	45.77	Cellulose.....	17.52
Ether extract	2.17	Other carbohydrates	36.13
Crude fiber.....	14.66	Calcium	0.56
Ash	19.32	Phosphorus	0.24

The oxalic acid content of the beet tops decreased during the curing process. This decrease has also been noted in other reports. It may be one reason why better results were observed when beet tops were not fed or pastured until a week or 10 days after harvest. This decrease, observed during the curing, was as follows:

	<i>Per cent moisture</i>	<i>Per cent oxalic acid⁴</i>
November 25, 1940.....	11.32	8.04
November 28, 1940.....	10.75	5.45
December 8, 1940.....	5.18	4.87
December 16, 1940.....	11.90	4.16

Table 2 gives the percentage of apparent digestibility found for the various constituents. Except for lignin, the digestibility of the various constituents agreed very closely for each steer.

⁴ Method: Extraction according to: Widmark, E. M. P., and G. Ahldin. *Biochem. Zeit.* 265:241. 1933. (HCl extraction.) Isolation by Homberg procedure described in: *Biochem. Zeit.* 182:263. 1927.

The apparent digestibility of the protein, as determined in the trial, is 69.3, compared with 74.0 as determined by digestion by pepsin and hydrochloric acid *in vitro*. The apparent digestibility as corrected for metabolic nitrogen in the feces, through determination of pepsin hydrochloric digestible material in the feces, is 79.0. The coefficient of digestibility found by correcting for metabolic nitrogen according to the formula of Harris and Mitchell (1941) is 87.4, and this probably most nearly represents the true digestibility of the protein.

Table 2
APPARENT DIGESTIBILITY OF BEET TOPS, 15-DAY COLLECTION PERIOD

Steer	Dry matter	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber	Lignin	Cellulose	Other carbohydrates
	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
No. 1.....	74.6	69.8	82.6	41.5	74.9	16.4	83.7	88.0
No. 2.....	74.2	68.8	81.6	36.7	74.4	—10.3	81.7	91.2
Average.....	74.4	69.3	82.1	39.1	74.6	3.1	82.7	89.6

Experimental evidence indicates that the calcium in plants which contain oxalic acid in relatively high concentrations—for example, spinach—is unavailable to man and rats because of the insoluble calcium oxalate that forms. Since beet leaves are high in oxalic acid, it has been commonly recommended that calcium carbonate be added to rations containing beet tops or beet-top silage. Calcium and phosphorus balance experiments were run in an attempt to study the possible effect of oxalic acid on mineral metabolism.

Although the amount of oxalic acid present in the feed greatly exceeded that required to precipitate all the calcium in the ration, in the digestion and metabolism experiment, significant assimilation and storage of calcium and phosphorus occurred. Blood calcium and phosphorus values were normal during the trial. Apparently, therefore, ruminants can tolerate excessive amounts of oxalic acid in plant material without suffering the loss of calcium which has been observed in balance trials with rats and humans. Perhaps the oxalic acid is destroyed during fermentation in the rumen, as it is in the process of ensiling. On the other hand, at the Colorado Agricultural Experiment Station (Morton, Osland, and Tom, 1936) scouring among steers was reduced by the addition of 0.1 pound of calcium carbonate daily to rations containing beet tops.

Nitrogen balances were also made to determine the utilization of protein. The results of these tests appear in table 3. Nitrogen balances were positive and were sufficient to increase muscle and other lean-tissue growth at a rate of 0.5 to 1.0 pound daily.

Table 4 compares the coefficients of apparent digestibility among the constituents of beet tops as found for cattle in the present experiment and for sheep

Table 3
DAILY NITROGEN, CALCIUM, AND PHOSPHORUS BALANCES

Element	Intake	Output			Balance	Amount retained
		Feces	Urine	Total		
	grams	grams	grams	grams	grams	per cent
Steer no. 1						
Nitrogen.....	117.60	35.5	65.80	101.30	+16.30	13.9
Calcium.....	20.84	17.5	0.43	17.93	+ 2.91	14.0
Phosphorus.....	9.87	6.0	0.91	6.91	+ 2.96	30.0
Steer no. 2						
Nitrogen.....	115.80	36.17	70.94	107.11	+ 8.69	7.5
Calcium.....	20.85	17.60	0.30	17.90	+ 2.95	14.1
Phosphorus.....	9.67	6.12	0.79	6.91	+ 2.76	28.5

Table 4
COEFFICIENTS OF APPARENT DIGESTIBILITY OF BEET TOPS AS FOUND IN
THE EXPERIMENT WITH CATTLE COMPARED WITH RESULTS
COMPILED FROM EUROPEAN SHEEP TRIALS*

	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber
	per cent	per cent	per cent	per cent
Cattle:				
Tops alone, author's data.....	69.3	82.1	39.1	74.6
Sheep:				
Tops alone, unwashed.....	46.3	80.2	39.4	21.3
Tops alone, washed.....	58.8	76.5	63.5	14.9
Tops, fed in mixed ration—range.....	60.2-74.0	75.5-82.6	6.5-62.8	61.3-86.0
Average of 11 trials (24 animals).....	63.9	79.6	34.2	66.4
Beet-top silage, average of 8 trials (16 animals).....	68.4	82.1	51.5	77.3

* Sources of data: Honcamp, F., O. Meier, W. Schramm, and W. Wohlbier. Weitere Untersuchungen über den Einfluss des Waschens von frischen und ungesäuerten Zuckerrübenkraut; auf Zusammensetzung und Verdaulichkeit desselben sowie über die hierbei entstehenden Verluste an Roh- und verdaulichen Nährstoffen. Die Tierernährung 5:65-86. 1933.

Honcamp, F., and W. Schramm. Neuere Untersuchungen über den Fütterwert des Zuckerrübenkrautes. Die Tierernährung 3:174-207. 1931.

Von Kurelec, V. Über den Fütterwert gewaschener und getrockneter Zuckerrübenblätter und Köpfe. Fortschritte der Landw. 7:221-222. 1932.

Honcamp, F., B. Gschwendner, and H. Müllner. Untersuchungen über den Fütterwert von getrocknetem, frischem und eingesäuertem Rübenkraut und Rübenblatt und über die Verluste an Roh- und verdaulichen Nährstoffen beim Einsäuern. Land. Ver. Stat. 88:305-78. 1916.

Woodman, H. E., and J. W. Bee. The nutritive and manurial values of sugar beet tops. Jour. Agr. Sci. 17:477-88. 1927.

by European investigators. Although the average for the sheep experiments shows somewhat lower digestibility than was found in the present trials with cattle, the sheep trials had such varying results that the difference is not significant. Moreover, some of the findings for sheep agreed very well with those for the cattle experiment. These data indicate that cattle and sheep showed no fundamental difference in ability to digest the nutrients of sugar-beet tops.

The following tabulation shows the digestible protein and total digestible nutrients in 100 pounds of beet-top dry matter used in the cattle trials, together with the digestion coefficients applied to average analyses.

Feeds	<i>Pounds of digestible protein</i>	<i>Pounds of digestible nutrients</i>
Beet tops used in digestion trial	13.5	63.9
Average of 6 California samples (steers) ⁵	7.4	64.2
Average of 48 American and European samples (steers) ⁵	9.7	59.2
Average of 48 American and European samples (sheep) ⁶	9.0	56.4
Alfalfa hay, all analyses ⁷	11.7	55.6

The average coefficients of 24 sheep trials, applied to average analyses, and the average value of alfalfa hay are given for comparison. Throughout, the total digestible nutrients in the dry matter of beet tops was greater than that in alfalfa-hay dry matter. The protein content of the tops used in the digestion and metabolism experiment was unusually high, perhaps because the tops were grown on well-fertilized soil and harvested when very green and succulent.

Feed-Replacement Value of Beet-Top Silage. On the basis of the digestion trials and average composition, 1 ton of beet-top silage containing 70 per cent moisture would have a feed-replacement value equivalent to about 450 pounds of barley or 700 pounds of alfalfa hay. In other words, the well-conserved tops from 1 ton of beets would have a feed-replacement value of about 150 pounds of barley or 230 pounds of alfalfa hay. These amounts, with a 15-ton beet yield, are equivalent to about 1 ton of barley per acre, or well over 1.5 tons of alfalfa hay. The yield of silage varies but, for the most part, should be 3 to 5 tons to an acre.

Maynard (1944) summarizes data on the feed value of beet by-products. His figures, based on digestible nutrient content, are derived from feeding tests. They are expressed in terms of the amounts of corn grain and alfalfa replaced by the beet by-products in the ration. The summary included 106 experiments, and the results are shown in table 5. Thus, in livestock-feed production, the by-products of the sugar-beet industry are equal to the primary product of many feed crops.

Utilization of Beet Tops. The pasturing of scattered tops in the field is a wasteful practice even under the best possible pasture management. Many of the leaves are lost by drying, shattering, and trampling. The fertilizer value of tops left on the field is recognized, but much of this can be returned to the soil in the form of manure derived from animal feeding. Furthermore, beet tops are less efficiently utilized by livestock if fed as the sole ration than if

⁵ Based on average analyses and digestion coefficients obtained with steers.

⁶ Based on average analyses and average coefficients of digestibility from 24 sheep trials.

⁷ Morrison, F. B. Feeds and feeding. Appendix table 1. The Morrison Company, Ithaca, New York, 1936.

incorporated in a ration containing a variety of feeds. As pointed out before, yearling steers in the digestion and metabolism experiment ate about 60 per cent crowns and 40 per cent leaves, when given enough beet tops to permit free choice. Since the actual proportion of crowns and leaves in beet tops is just the reverse, the digestion and metabolism experiment indicates the waste of leaves in the field.

It is estimated that less than 40 per cent of the 1942 acreage of beet tops was utilized for feed, and that about 80 per cent of the acreage pastured was used

Table 5

**AMOUNTS OF CORN GRAIN AND ALFALFA REPLACED BY SUGAR-BEET
BY-PRODUCTS IN FEEDING TESTS**

	Corn and alfalfa replaced by by-products of 1 ton of beets		Corn and alfalfa replaced by by-products from 13½ tons per acre average yield of beets	
	Corn	Alfalfa	Corn	Alfalfa
	pounds	pounds	pounds	tons
Beet tops.....	46	150	620	1.01
Wet pulp*.....	41.6	99.5	560	0.67
Dried pulp*.....	80.2	37.6	1,274	0.25

* To compute total replacement value of beet by-products, one should add either the value for wet pulp or the value for dried pulp to that in the tops. The difference in replacement value of wet and dried pulp was dependent largely on the way they were used in the rations, rather than on difference in feeding value. Dried pulp is commonly used to replace concentrates in fattening rations, while wet pulp, because of its bulk, mainly replaces roughage.

by beef cattle. The estimated average yield of beef per acre was 50 pounds. The maximum utilization obtained by pasturing scattered tops is 90 to 100 pounds of live-weight gain per acre. If tops are harvested, made into silage, or otherwise conserved, and are fed in mixed rations, the yield of beef or lamb per acre may be as much as 150 to 250 pounds. Such practice has further advantages. It prevents delay in soil preparation in the fall, and eliminates the spread of plant disease and noxious weeds which sometimes results from pasturing. It permits conservation of manure and also meets the problem of unfavorable weather conditions which may interfere with pasturing.

The practice of making beet-top silage by stacking the unchopped tops on the ground in a place convenient for feeding has become increasingly popular in other beet-growing states. Stacking in this way demands that the beet tops be green or only slightly wilted. If the tops are allowed to lose too much moisture, they will mold and decompose in the stack. As the silage settles, successive layers should be added until the final stack is at least 7 feet high. It is important to attain enough height and weight in the stack so that the tops pack tightly to exclude air. To produce good silage, the tops should be as free of dirt as possible. A satisfactory stack, made in Monterey County in 1941, is shown in figure 2. This stack, with straight sides, was properly built; when it was completely settled, it was so well sealed that spoilage was reduced to a minimum.

The silage apparently was little affected by winter rains and when fed, about one year later, was considered in excellent condition.

Silage may also be made in a pit silo, a board-up silo, or in any aboveground silo. Chopping the tops with an ensilage cutter may distribute the sugar more thoroughly throughout the mass, and thus facilitate fermentation. If chopping is done, some sort of retaining walls are necessary. The top of chopped silage may be covered with wet beet pulp to make a seal.



Fig. 2.—This well-built stack of beet-top silage was harvested in the fall, and fed out the next summer. (Photo by Reuben Albaugh, Assistant Farm Advisor, Monterey County.)

There have been reports from stockmen of from two to three times more production from beet-top silage than from pasturing in the field. Data (Aune, 1940; Maynard, 1940) also showed a return of \$1.25 to \$1.40 in feed-replacement value per ton of beets harvested, as compared with a market value of \$0.25 to \$0.30 per ton of beets in the field. These values were based on comparatively low grain and hay prices.

According to Maynard (1942), the cost of ensiling beet tops in 1942, estimated by 43 growers in the Colorado district, ranged from \$1.75 to \$8.00 per acre and averaged \$4.10. The estimated cost per ton of beets was \$0.11 to \$0.50 and averaged \$0.23. Under ordinary conditions, a yield of 3 to 5 tons of silage per acre may be expected.

The loss from ordinary methods of ensiling has been reported as 10 to 30 per cent of the dry matter, according to the depth of the silage and the amount of area exposed. The average loss in stacked silage is reported to be about 15 per cent.

The Agricultural Extension Service in Monterey County reported that the

field drying and curing of tops has proved practical. In 1943, one operator obtained 44 tons of cured tops from 12.7 acres yielding 13.5 tons of beets per acre. The tops were piled by hand and hauled 12 miles by truck. The total cost, including \$6.00 per acre for the tops, was \$10.37 per ton. Another operator, with a haul of only 2 miles, obtained 3 tons per acre of cured tops for a harvesting and hauling cost of \$4.39 per ton. Baling cured tops in the field appears practicable. In one instance, 3.8 tons per acre of baled tops containing 27 per cent moisture were obtained from a field yielding 28 tons of sugar beets per acre. The entire operation of gathering, piling, and baling cost \$3.78 per ton. The tops were allowed to dry in the field for 10 days, then were gathered into small piles and allowed to cure for 2 weeks longer (Albaugh, 1943).

Beet tops have been used successfully in rations for growing cattle. They also have been used for fattening cattle, for wintering pregnant ewes, for fattening lambs, and for feeding dairy cattle. On pastured tops alone, cattle may be expected to gain from 1.0 to 1.5 pounds daily, and lambs, 0.18 to 0.22 pounds daily. If livestock have access to hay or to dry stubble, or are fed supplementary grain on beet-top pasture, variety is added and an increase in gain is accomplished.

For best results, livestock pasturing should follow harvesting by a week or 10 days, and the area should be fenced so that it is cleaned up in 10 days to 2 weeks. Good utilization requires keen judgment, since pasturing an area one day too long may cost many pounds of gain, and moving one day too soon may sacrifice many pounds of feed. Waste in pasturing windrowed or bunched beet tops is less than in pasturing tops scattered in the field.

Cattle are observed to consume large quantities of water and to urinate frequently when they graze on beet tops. In two periods of 5 days' duration, the daily water consumption by two year-old steers was 14 and 22 gallons respectively. The daily water intake of the steers tested in the digestion and metabolism experiment averaged 7 gallons, and the daily urine output was from 5.5 to 5.8 gallons. The presence of betaine and other nonprotein nitrogen compounds, together with a high content of soluble minerals in the tops, probably contributes to the polyuria as well as to the laxative effect. This emphasizes the need for abundant water supply for animals grazing on beet tops.

It is common for both cattle and sheep on pasture to choke on hard crowns. Losses may be heavy unless careful watch is kept, and choked animals are treated at once. In silage, the crowns remain soft, a factor which eliminates trouble from hard crowns.

In fattening cattle and lambs, the use of mixed rations in which beet-top silage replaces about one half the hay normally fed, or one fourth the dry-feed equivalent of the total ration, has produced gains and finish comparable with those obtained from standard rations. The usual allowance of silage for steers is 20 to 30 pounds daily; for lambs $1\frac{1}{2}$ to 2 pounds daily. The addition of about 0.1 pound daily of calcium carbonate or ground oyster shell for cattle and 0.01 pound for sheep costs little and may be beneficial. Because of high

digestibility and low fiber content, beet tops may be depended on to replace part of the grain ration as well as the roughage.

Beet-top silage may be used in livestock rations in the same way as is corn or other silage. Since the tops are higher in digestible protein than corn or sorghum silage, less protein concentrate is needed with them to balance the rations.

Good results from feeding beet-top silage to dairy cows have been reported from the Colorado Agricultural Experiment Station by Dickey (1941). He recommends feeding from 20 to 30 pounds daily (with hay and grains) according to the size of the animal, and prefers silage to dry tops.

One negative aspect to the feeding of beet tops to dairy cows is the presence of betain, the methyl amines from which may cause a fishy flavor in the milk. Trout and Taylor (1935) found this off-flavor noticeable when cows were fed 25 pounds, or more, of beet tops daily, and most pronounced when the feed was given just before milking. According to the same writers, beet tops should be fed after milking; then, under the ordinary conditions of feeding, the milk is not enough off-flavor to merit rejection.

In California, the chief obstacles to conserving and efficiently utilizing sugar-beet tops—which produce from one and one half to two times the digestible nutrients obtained in beet pulp from the same amount of beets—have been the labor cost of gathering the tops, a failure to appreciate the true value of the tops, and a lack of economic necessity as an urge. The mechanical harvesting of beets should facilitate the harvesting and conservation of beet tops; and continued development of a livestock-feeding industry, in connection with beet growing, should contribute much toward sustained yields and economic stability.

SILOED SUGAR-BEET PULP

Effect on Storage Loss of Adding Molasses to Wet Beet Pulp in Small Pit Silos. The ordinary method of storing wet beet pulp in open silos involves heavy losses through continual fermentation and oxidation. Methods for minimizing these losses have been studied by R. D. Jones of the Spreckels Sugar Company. Several small pit silos were constructed, each about 10×12 feet in area, 6 feet in depth, and 10 tons in capacity. Carefully controlled tests were made on preservation through the addition of varying amounts of cane molasses (2.5, 5.0, and 7.5 per cent) and of inorganic acids at the time the pulp was placed in the silos. Treatment with inorganic acid appeared impractical, since the acids are difficult to handle and will corrode metal machinery.

The pulp was placed in the silos in autumn; and, at intervals during the winter, samples were taken for chemical analyses and for observations on the texture of the pulp. The wet pulp direct from the factory contained about 92 per cent moisture. After 6 to 8 months in the silo, the figure was about 87 per cent.

The average loss in four tests with siloed pressed pulp was 51.9 per cent of the total solids and 58.5 per cent of the total organic matter. The correspond-



Fig. 3.—A large-scale feeding enterprise adjacent to a sugar factory.

ing loss in an average of twelve tests of pulp, to which 2.5 to 7.5 per cent of molasses had been added, was 25.6 per cent of total solids and 30.1 per cent of total organic matter. These treated pulps averaged about 75 per cent pulp solids and 25 per cent molasses solids. The treated pulp retained its original consistency, whereas the untreated pulp became a nearly homogenous cheese-like mass.

These tests showed considerable promise of reducing storage losses and also of producing a pulp which had the odor of common silage, and not the usual objectionable odor of siloed pulp. Therefore, digestion and feeding tests were run on treated and untreated pulps.

Digestion Trials with Treated and Untreated Siloed Beet Pulp. Four yearling wethers were used for digestion trials in this experiment. In each trial, chopped alfalfa hay was fed with the pulp. The first trial was with ordinary siloed pulp; the second, with pulp to which 2.5 per cent molasses had been added at time of siloing. In a third trial, in order to determine the digestibility of the hay fed as a part of the ration, chopped alfalfa hay was given alone. The sheep had a few days' rest between trials. Each trial consisted of a 7-day preliminary period and a 10-day collection period. Each sheep received 2,600 grams of wet pulp and 500 grams of chopped hay daily, except during the third trial, when the ration was 1,000 grams daily of chopped hay alone.

The wet pulp was hauled directly from the factory silo in barrels, as needed, and was stored in a cool place. The required amount was weighed out at each feeding, and a sample was taken daily for moisture determination. The

chopped alfalfa hay was thoroughly mixed at the beginning of the trial, and aliquot samples were taken for chemical analysis. The hay, weighed out in sufficient 500-gram portions for the entire trial, was placed in paper bags.

The feces were collected in rubber-lined canvas bags which were held in place by a special type of harness. These bags were emptied morning and evening at feeding time. The feces from each sheep were dried in an electric oven at 80°C for 24 hours, then were placed in a galvanized can. At the close of the collection period, all feces from each sheep were weighed, and samples were taken for moisture determination. The material was then ground by means of a small hammer mill, and samples were taken for chemical analysis. From these results, the coefficients of digestibility were determined for each sheep, allowance being made for the digestibility of the hay.

The chemical analyses of the feeds are shown in table 6; the coefficients of digestibility, in table 7; and the total digestible nutrients, compared with some common feeds, in table 8.

In these digestion trials there were, as might be expected, some variations among the individual sheep. As shown in table 7, sheep no. 4 had consistently higher digestion coefficients with both treated and untreated siloed pulp. In the trial on alfalfa alone, this animal was lower than the others, and this fact may account for apparently higher digestion when correction was made for the hay fed in the pulp trials. Results from the other three animals agreed

Fig. 4.—A simple and economical feed lot beside a levee, which provides drainage. The owner utilizes wet pulp from the sugar factory and markets his beet tops, hay, and other farm feeds through fattening cattle.



Table 6
PERCENTAGES OF SOME CONSTITUENTS OF THE FEEDS

Feeds	Dry matter	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber
Wet siloed beet pulp without molasses.....	12.34	1.79	4.37	0.43	5.45
Wet siloed beet pulp with molasses (2½ per cent)....	9.75	1.01	5.56	0.09	2.56
Alfalfa hay.....	87.00	16.61	33.95	1.75	24.56

Table 7
APPARENT DIGESTIBILITY OF SILOED WET BEET PULP AND ALFALFA HAY

Feed and sheep number	Dry matter	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber
	per cent	per cent	per cent	per cent	per cent
Siloed wet beet pulp without molasses:					
Sheep 1.....	75.9	61.7	79.4	0.6	87.5
Sheep 2.....	75.2	57.4	77.4	....	88.0
Sheep 3.....	73.9	57.5	79.3	4.4	84.5
Sheep 4.....	81.0	66.9	87.7	9.2	89.5
Average.....	76.5	60.9	80.9	....	87.4
Siloed wet beet pulp with 2.5 per cent molasses:					
Sheep 1.....	77.8	55.2	86.3	....	76.0
Sheep 2.....	78.6	54.7	82.3	....	83.9
Sheep 3.....	80.1	56.0	85.8	....	83.4
Sheep 4.....	84.8	65.0	96.0	....	81.3
Average.....	82.8	57.7	87.6	....	81.2
Alfalfa hay:					
Sheep 1.....	67.1	78.3	76.3	61.7	49.0
Sheep 2.....	65.4	76.4	75.4	62.0	47.6
Sheep 3.....	65.7	77.4	73.9	58.5	48.0
Sheep 4.....	63.6	75.8	70.6	55.7	47.4
Average.....	65.5	77.0	74.1	59.5	48.0

closely. The average of the four sheep shows that the digestibility of the crude fiber is particularly high, as is that of all types of root crops. The fiber in the siloed pulp was somewhat more digestible than in the molasses pulp, whereas the reverse was true of the nitrogen-free extract. As other work has shown, the addition of readily fermentable sugar renders crude fiber less digest-

ible, presumably by diverting the activity of rumen bacteria. The coefficient was rather high for both types of pulp—87.4 and 81.2 respectively.

Ether extract is present in such small amounts in wet pulp that reliable results could not be obtained. There was little difference in the digestibility of the crude protein content of the two types of pulp. As table 8 shows, the

Table 8
TOTAL DIGESTIBLE NUTRIENTS OF THE WET PULPS AND A
FEW COMMON FEEDS FOR COMPARISON

Feeds	Total dry matter in 100 pounds	Digestible nutrients in 100 pounds		Digestible nutrients in 100 pounds of dry matter	
		Crude protein	Total digestible nutrients	Crude protein	Total digestible nutrients
Wet siloed beet pulp without molasses	12.3	1.1	9.4	8.9	76.4
Wet beet pulp with 2.5 per cent molasses	9.8	0.6	7.6	7.8	77.6
Dried beet pulp*	92.0	4.5	71.8	5.2	78.0
Dried molasses beet pulp*	91.8	6.1	74.3	6.7	81.0
Alfalfa hay	87.0	12.8	52.1	14.7	59.9
Barley, Pacific Coast	90.0	7.8	78.0	8.7	86.7
Corn silage, dent well matured*	28.3	1.3	18.7	4.6	66.1
Alfalfa green, all analyses*	25.4	3.4	14.7	13.4	57.9

* F. B. Morrison. Feeds and feeding. Appendix table 1. The Morrison Publishing Company, Ithaca, New York. 1936.

siloed pulp contained 9.4 pounds of total digestible nutrients; the molasses pulp only 7.6 pounds. When calculated on a moisture-free basis, however, the wet beet pulp with molasses contained slightly greater total digestible nutrients.

Feeding trials (Herms and Jones, 1940) have shown equal value for dried molasses pulp and siloed wet pulp. The latter, however, gave slightly better results and was more efficiently utilized than fresh, unfermented wet pulp.

Lamb-Feeding Trial. To test the feed value and palatability of the wet molasses pulp, a lamb-feeding trial was conducted in coöperation with W. H. Herms of the Agricultural Extension Service, R. D. Jones of the Spreckels Sugar Company, and Henry Gasser, lamb feeder who owned the lambs. In this test, the 5 per cent molasses pulp was used in comparison with the regular siloed pulp from the factory silo. The results are presented in table 9.

The sheep used in these trials had been fed on plain siloed pulp for about 6 weeks before the trial began. At that time, lot 1 was changed to the siloed pulp with molasses, and somewhat less pulp was consumed during the first week of the experiment. Subsequently, both lots consumed about the same amount of feed.

The lambs were average feeders, grading medium to good; and both lots made very satisfactory gains. The lambs in lot 1, which received the wet pulp with molasses, consumed less hay and, in turn, less dry matter per day. In lot 1, a gain of 100 pounds required 617.7 pounds of dry matter; in lot 2, where regular siloed pulp from the factory was used, the same amount of gain required 701.5 pounds—a saving of 83.8 pounds, or 13.6 per cent, in favor of lot 1.

Table 9

SUMMARY OF LAMB-FEEDING TRIAL

Comparison of Wet Pulp Siloed with Molasses and Wet Pulp Siloed without Molasses, February 1 to March 10, Inclusive, 1942 (38 days)

	Lot 1* Feed: Siloed pulp with 5 per cent molasses	Lot 2† Feed: Siloed pulp without molasses
	pounds	pounds
Average final weight per lamb.....	85.8	86.1
Average initial weight per lamb.....	70.7	70.8
Average gain per lamb.....	15.1	15.3
Average daily gain per lamb.....	0.397	0.402
Feed consumed per lamb per day:		
Ground barley.....	0.73	0.73
Beet pulp.....	6.1	6.1
Chopped alfalfa hay.....	1.33	1.57
Average daily dry matter per lamb.....	2.42	2.77
Feed consumed per 100 pounds' gain:		
Ground barley.....	183.8	182.3
Beet pulp.....	1,527.0	1,514.4
Chopped alfalfa hay.....	335.1	388.6
Total dry matter per 100 pounds' gain.....	617.7	701.5

* 98 lambs.

† 97 lambs (1 lamb died).

Although the trial covered only the last 38 days these lambs were on feed, a difference in economy of gain was indicated in favor of the wet pulp treated with 5 per cent molasses. This result agrees with the digestion-trial data, which showed more digestible nutrients in the dry matter of pulp, to which 2.5 per cent molasses had been added, than in untreated pulp.

Effect of Adding Molasses, Urea, and Barley on the Type of Fermentation in Wet Beet Pulp, and on Ensiling Losses. Cullison (1944), in making silage from sweet sorghum, observed that the fermentation continued over a long period. To test whether or not this was caused by lack of available nitrogen for the organisms that produce lactic acid and acetic acid, urea was added at the time of ensiling. It was found that the addition of urea shortened the fermentation time, apparently changed the proportion of the types of acids formed, and increased the palatability and nutritive value of the silage.

Conceivably, since beet pulp is relatively poor in protein, the addition of readily available nitrogen might improve the rate and the type of fermentation and thus decrease the losses. The moisture content of the plant material is another factor in silage making. In general, moisture contents of 65 and 75 per cent appear to be most favorable.



Fig. 5.—A group of good-grade ranch-fed steers. They were fed an average of 8.0 pounds alfalfa hay, 5.3 pounds rolled barley, 39 pounds wet beet pulp, 1.8 pounds molasses, and 0.24 pound of cottonseed meal daily. They gained an average of 2.08 pounds daily over a 147-day feeding period, and the carcass yield was 57.6 per cent.

With these considerations in mind, some small-scale pilot experiments were conducted during 1945 and 1946. The first series of tests was made with fresh, pressed beet pulp containing about 87 per cent moisture. Fifteen hundred grams of wet pulp were mixed thoroughly with varying quantities of urea, molasses, and with combinations of the two. The material was tightly packed in 2-quart Mason jars, topped with screw-top covers left unsealed. These jars were placed in an incubator and maintained at about 37°C from October 11 to November 27, when the fermentation and moisture losses and the acidity determinations were made. Table 10 presents the results.

Addition of urea increased the porportion of volatile acids; but, judging from the odor, it did not increase the butyric acid. Since the pH value was increased slightly, these silages would have been less acid to the taste.

In these tests, molasses added to the extent of 1 to 1.66 per cent of the original weight of the pulp produced a change in a similar direction, but 4 per cent molasses definitely inhibited acid production.

The combination of molasses and urea resulted in fermentations not very

different from those obtained with urea alone. There was one exception: when 4.0 per cent molasses was used, a depressing effect on total acid production was again evident, although less marked than in the trials with urea.

Assuming the conversion of urea to protein by microorganisms, either in the silage or in the rumen of cattle, the 0.067, or 0.133, and 0.266 per cent urea added could be considered equivalent to the addition of about 0.2, 0.4, and

Table 10
EFFECT ON FERMENTATION IN WET BEET PULP OF ADDING
MOLASSES AND UREA

(Fruit-jar tests with 1,500 grams of pulp, 6 weeks at 37° C)

Treatment	pH	Volatile acid*	Fixed acid†	Total acid	Fermentation loss
		per cent	per cent	per cent	per cent
Wet beet pulp alone	4.1	0.91	0.99	1.90	4.8
Wet beet pulp with urea:					
Urea, 0.133 per cent	4.2	1.24	0.66	1.90	2.7
Urea, 0.266 per cent	4.3	1.32	0.38	1.70	1.3
Wet beet pulp with molasses:					
Molasses, 1 per cent	4.3	1.01	0.61	1.62	4.3
Molasses, 1.66 per cent	4.1	0.83	0.49	1.32	3.0
Molasses, 4 per cent	4.6	0.34	0.22	0.37	3.4
Wet beet pulp with molasses and urea:					
Molasses, 1.0 per cent; urea, 0.067 per cent	4.0	1.07	0.63	1.73	2.7
Molasses, 1.0 per cent; urea, 0.133 per cent	4.2	1.05	0.45	1.50	3.0
Molasses, 1.0 per cent; urea, 0.266 per cent	4.3	1.17	0.68	1.85	2.7
Molasses, 1.66 per cent; urea, 0.133 per cent	4.1	1.09	0.63	1.72	2.5
Molasses, 4.0 per cent; urea, 0.133 per cent	4.1	0.84	0.77	1.61	4.5

* Calculated as acetic acid.

† Calculated as lactic acid.

0.8 per cent protein respectively, or 1.5, 3.0, and 6.0 per cent protein in relation to beet-pulp dry matter.

The second series consisted of three tests, using 214 to 224 pounds of pressed beet pulp which was mixed with urea and molasses, and with 10 per cent and 14 per cent rolled barley. The mixtures were tightly packed in metal barrels. On the top of the barrels containing rolled barley and pulp, a thin layer of whole barley was sprinkled. This sprouted, and the roots made a mat 2 to 3 inches deep. The barrels were covered with metal lids, left unsealed. The mixtures were placed in the barrels September 11, 1945, and were removed August 12, 1946. Table 11 shows the results.

In all cases, the volatile fermentation and moisture losses were low. The pH,

as well as the volatile, nonvolatile, and total acid were within the range for good silage. There was no provision for drainage. Since the molasses-urea-pulp mixture was very sloppy, 30 per cent of the entire weight was poured off as liquid. Afterward, when the mixture stood for a short time, free fluid again accumulated. The amount was not accurately determined; but at least 40 to 50 per cent of the original weight would have been lost if drainage had been permitted for any length of time. This recalls a common observation in large

Table 11
EFFECTS OF ADDING MOLASSES AND UREA, AND OF ADDING 10 AND 14 PER CENT OF BARLEY, ON FERMENTATION AND LOSS IN ENSILING PRESSED BEET PULP

Treatment	pH	Volatile acid*	Fixed acid†	Total acid	Fermentation loss‡	Total loss
		per cent	per cent	per cent	per cent	per cent
Wet beet pulp with molasses 1 per cent, urea, 0.13 per cent.	4.0	1.56	0.63	2.19	3.0	40-50§
Wet beet pulp with 10 per cent rolled barley.	3.9	1.35	0.54	1.89	1.2	6.0
Wet beet pulp with 14 per cent rolled barley.	3.9	1.56	0.69	2.25	2.1	7.0

* Calculated as acetic acid.
† Calculated as lactic acid.
‡ Moisture and fermentation gases.
§ Thirty per cent was poured off; more accumulated on standing. On the basis of a small laboratory test, the total drainage would have been about 50 per cent.

pits, where liquefaction and drainage occur over a long period, yet the moisture content of the fermented mass remains relatively constant at 87 to 88 per cent.

The outstanding result of the trial was that in the pulp-barley mixture the spoilage and loss, which amounted to 6 or 7 per cent of the original weight, was confined mostly to about 2 inches of moldy material on the top. Below this, the silage appeared bright, the beet-pulp shreds retained their form, and no fluid accumulated in the bottom of the barrels. Except for the top layer, all the ensilage was fed out and gave every indication of being a desirable product. The addition of 10 per cent of rolled barley reduced the moisture content of the original mixture to about 80 per cent; 14 per cent barley, to about 77 per cent. There was a marked reduction in objectionable odor of the ensilage as compared with ordinary ensiled beet pulp.

A test was made coöperatively with the Fontana Ranch Company, Collinsville. To approximately 100 tons of wet pulp, 10 tons of ground barley were added. The mixture was placed in a corner of the huge open reservoir in November, 1946, and fed out in August, 1947. The pulp siloed with barley appeared to be very desirable feed, of good texture, and with little of the usual siloed pulp odor. Quantitative data on input and recovery were inadequate, but it was evident that loss was very great. The final depth was only 3 feet so

that surface exposure was excessive. It was also exposed to about 15 inches of rain during the winter. Since, in the laboratory trials, there was very little fermentation loss and none from liquefaction and drainage, it would appear that leaching, including the organic acids, by rain may be a very important factor contributing to continued fermentation, disintegration, and loss from the open silo.

SUMMARY

Digestion and metabolism experiments with beet tops were conducted with two beef steers. The beet tops used contained, on the dry basis, 40 per cent crowns and 60 per cent leaves. The following average coefficients of digestibility were found: dry matter, 74.4; crude protein, 69.3; nitrogen-free extract, 82.1; ether extract, 39.1; and crude fiber, 74.6. When the nitrogen-free extract and crude-fiber fractions were divided, the average coefficients of digestibility were as follows: lignin, 3.1; cellulose, 82.7; and other carbohydrates, 89.6. Tables showing the average composition and variability of beet tops and beet-top silage are presented and discussed.

According to the average composition of beet tops and the digestibility found in this trial, 100 pounds of dry matter contain 9.7 pounds of digestible protein and 59.2 pounds of total digestible nutrients. The values found confirm European results obtained with sheep. The tops from a ton of beets have a potential feed-replacement value equivalent to about 150 pounds of barley or 230 pounds of alfalfa hay.

In balance experiments, significant amounts of calcium and phosphorus proved to be retained, although the tops had more oxalic acid than would be necessary to render all calcium unavailable. The results suggest that oxalic acid may be destroyed in the rumen. Nitrogen balances were positive and equalled about 0.5 to 1.0 pounds' daily gain in lean tissue.

Means are discussed for conserving and utilizing this large but wastefully used feed resource—a resource which not only might promote an increased production of animal products, but also might increase the productive and economic stability of the beet-growing and sugar-manufacturing industries.

According to data obtained by the Spreckels Sugar Company, the loss of wet-beet-pulp nutrients in the silo may be reduced at least 50 per cent by the addition of 2.5 and 7.5 per cent of molasses. The pulp so treated did not become cheeselike in texture, nor did it have the objectionable odor of ordinary siloed beet pulp.

The coefficients of apparent digestibility found with sheep for untreated wet siloed beet pulp were as follows: dry matter, 76.5 per cent; crude protein, 60.9 per cent; nitrogen-free extract, 80.9 per cent; and crude fiber, 87.4 per cent. The addition of the readily fermentable molasses may have caused a slight decrease in digestibility of crude fiber. On the same moisture basis, the treated pulp had slightly more total digestible nutrients than the untreated. The digestibility of these two wet pulps agreed with that reported for dried beet pulp and dried molasses beet pulp.

In feeding tests with lambs, the two types of wet siloed beet pulp showed about the same palatability. The addition of molasses not only decreased ensiling losses, but also enhanced the feed value of wet siloed pulp.

According to laboratory tests, the addition of urea, or a combination of urea and molasses may favorably affect the rate and type of fermentation, decrease losses, and increase the nutritive value of the siloed pulp.

The addition of 10 per cent and of 14 per cent rolled barley to pressed beet pulp containing about 87 per cent moisture, reduced the moisture content of the mixtures to about 80 and about 77 per cent respectively. These mixtures, fermented in barrels, were stored for nearly a year. The loss—6 to 7 per cent—was largely limited to a moldy layer about 2 inches thick on the top of the barrels. The silage was bright in color, and the shreds retained their form. Objectionable odor was greatly reduced. The product was palatable to cattle and gave every indication of being a desirable feed. No liquid accumulated at the bottom of the barrels. A similar test, with molasses and urea added to the pulp, resulted in a very sloppy product, with at least 40 to 50 per cent loss if drainage had been permitted.

A small-scale test of mixing barley with wet pulp under commercial conditions resulted in a good product, but there was heavy loss. This, compared with the laboratory results, suggested that exposure to rain may be an important factor contributing to the leaching of acids, continued fermentation, disintegration, and loss through drainage. Further large-scale tests are justified.

LITERATURE CITED

ALBAUGH, R.

1943. Results of utilizing sugar-beet tops for livestock feed in Monterey County. Agricultural Extension Service. (Mimeo.)

AUNE, BEYRE.

1940. Lamb feeding experiments conducted at U. S. Belle Fourche Field Station, Newell, South Dakota. *Through the Leaves* 28(5):171-76.

CRAMPTON, E. W., and L. A. MAYNARD.

1938. The relation of cellulose and lignin to the nutritive value of animal feeds. *Jour. Nutr.* 15:383-95.

CULLISON, A. E.

1944. The use of urea in making silage from sweet sorghum. *Jour. Anim. Sci.* 3:59-62.

DICKEY, H. C.

1941. Beet tops for dairy cattle. *Through the Leaves* 29(11):21-23.

HARRIS, L. E., and H. H. MITCHELL.

1941. The value of urea in the synthesis of protein in the paunch of the ruminant. *Jour. Nutr.* 22:167-82.

HERMS, W. M., and R. D. JONES.

1940. Sugar-beet-pulp steer-feeding trials. University of California Agricultural Extension Service. (Mimeo.)

MAYNARD, J.

1940. Beet tops worth much more to growers than market value indicates. *Through the Leaves* 28(5):177-78.
1942. The proper care and feeding of beet tops can reduce fattening costs this year. *Through the Leaves* 30(5):8-16.
1944. Feed value of sugar beet by-products in terms of grain and alfalfa hay replaced. *Through the Leaves* 32(3):20-24.

MORRISON, F. B.

1936. Feeds and feeding. 20th ed. Appendix table 1. The Morrison Company, Ithaca, N.Y.

MORTON, G. E., H. B. OSLAND, and R. C. TOM.

1936. Beet tops for fattening steers. *Colorado Agr. Exp. Sta. Press Bul.* 90:1-11.

RUSCHMANN, G., and G. GRÄF.

1931. Versuche zur Verbesserung eines Rübenblattfutters. *Fortschritte Landw.* 6:326-28.

TROUT, G. M., and G. E. TAYLOR.

1935. Effect of beet tops on flavor and odor of milk. *Michigan Agr. Exp. Sta. Quarterly Bul.* 18:37-45.

WIDMARK, E. M. P., and G. AHLÖIN.

1933. *Biochem. Zeit.* 265:241.